FIELD TRIALS OF FENVALERATE AND ACEPHATE TO CONTROL SPRUCE BUD MIDGE, *DASYNEURA SWAINEI* (DIPTERA: CECIDOMYIIDAE)

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ABSTRACT

Three concentrations each of fenvalerate and acephate were tested for efficacy against the spruce bud midge on black and white spruce in southcentral Alaska in 1985. Only the highest concentration of fenvalerate (0.025 percent), which is currently registered with the United States Environmental Protection Agency for forest use, provided significant protection.

INTRODUCTION

The spruce bud midge, *Dasyneura (Rhabdophaga) swainei* Felt, kills terminal and lateral vegetative buds of white spruce, *Picea glauca* (Moench) Voss, and black spruce, *P. mariana* (Mill.) B.S.P. (Furniss and Carolin 1977). Larvae emerge from eggs deposited on newly developing shoots, crawl to the shoot tips, and enter the host through the bases of new needles (Cerezke 1972, Clark 1952). Successful larvae migrate through shoot tissue to newly formed buds, feed on and kill the bud apical meristem, and overwinter usually singly in the still living, galled buds. Adults emerge in the spring from pupae in the galled buds and lay eggs as new shoots begin to elongate. The buds soon die, but they persist as gray, weathered, swollen galls.

Loss of terminal buds may result in reduced height growth (Cerezke 1972) and stem deformity because multiple leaders develop from lateral buds. Such effects are undesirable in trees grown for timber because reduced height growth in seedlings and saplings can delay height dominance over competing vegetation, and repeated stem deformities cause defects in harvested posts, poles, and logs.

This experiment was intended to determine whether registered concentrations (or formulations) of fenvalerate and acephate for control of seed, cone, and needlemining insects would effectively reduce damage by spruce bud midges. Fenvalerate, a synthetic pyrethroid, was chosen because of its low toxicity to vertebrates, except fish and amphibians, and its high toxicity to insects. It is rainfast on host foliage if applied as Pydrin® Emulsible Concentrate[1] diluted in water. Acephate was chosen because it is partially systemic (Lyon 1973), has low vertebrate toxicity, and is highly toxic to insects. If applied as Orthene® Tree and Ornamental Spray dissolved in water, some of the active ingredient is presumably absorbed within several hours by the host foliage and translocated to internal feeding sites of insects (Crisp *et al.* 1978), such as new needles.

MATERIALS AND METHODS

The area selected for the test was denuded by fire in 1959 but had revegetated naturally with black spruce and white spruce seedlings.

A total of 105 spruce seedlings ranging from 0.7 to 2.0 m in height and infested by spruce bud midge were examined, selected and labeled with numbered tags. Eleven trees were white spruce and 94 were black spruce. All were formerly infested and most had multiple leaders.

The trial was completely randomized. Fifteen trees, selected by numbers using a calculator programmed to generate random numbers, were assigned to each of 7 treatments.

Treatments were: a) 0.025%[2], b) 0.0125%, and c) 0.00625% fenvalerate aqueous dilutions; d) 1.0%[3], e)0.5%, and f)0.25% acephate aqueous solutions; and g) controls, without treatment. Insecticide formulations were mixed with water at ratios shown in Table 1.

The trees were treated after shoot elongation had begun, and formulations were applied by backpack hydraulic sprayer until runoff. Spray treatments were applied on 26 June, 1985 during still, clear weather in this order: f), e), d), c), b), and a). The sprayer was rinsed with water between treatments and with water and Nutrasol® between the acephate and fenvalerate treatments.

The trees were re-examined after bud flush on 17 June, 1986 to assess the efficacy of the insecticide treatments. The terminal bud formed in 1986 on the dominant leader of each tree was classified as infested or uninfested. Buds that were swollen and rosetted in a manner characteristic of bud midge damage (Clark 1952) and that did not form shoots in 1986, were considered infested. For comparison, the terminus of each leader dominant at the end of the 1984 growing season was examined. If a new leader had grown from the terminal bud in 1985, it was classified as uninfested. If the terminal bud formed in 1984 was dead and galled in a manner typical of bud midge infested buds, it was classified as infested. Furthermore, the upper 25 terminal buds combined on primary, secondary, and tertiary shoots of each test tree were classified as uninfested, currently infested, or formerly infested.

Numbers of infested terminal buds on the upper 25 primary, secondary, and tertiary shoots before and after treatment were analyzed by analysis of variance (ANOV). Post-treatment results were compared by Bonferroni's multiple pairwise comparison t-test with *Alpha* = 0.05. Data were also analyzed through analysis of covariance (ANCOV) using numbers of buds infested in 1984 or earlier as the covariate. Proportions of trees with an infested leader terminal bud were analyzed by paired treatments for significant differences by computing a critical Z statistic[4] with *Alpha* = 0.05. In the analysis of proportions, the condition of only one bud per tree, the terminal bud on the dominant leader, was considered.

Table 1. Insecticide concentrations and formulations in water, Alaska, 1985.

Insecticide	Treatment	Concentration	Formulation in water	
		percent	fl oz/gal	ml/l
Fenvalerate[1]	a)	0.025	0.110	0.860
	b)	0.125	0.055	0.430
	c)	0.0625	0.028	0.215
		percent	oz/gal	g/l
Acephate[2]	d)	1.00	0.107	0.799
	e)	0.50	0.053	0.400
	f)	0.25	0.027	0.200

[1] Pydrin® 2.4 Emulsible Concentrate
[2] Orthene® Tree and Ornamental Spray

[1] Trade names of commercial products are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

[2] Highest concentration has U.S. Environmental Protection Agency Registration No 201-401 for forest use.

[3] Highest concentration has U.S. Environmental Protection Agency Registration No. 239-2427-AA for general use.

[4]
$$Z = \frac{\hat{P}_1 - \hat{P}_2}{\left(\frac{\hat{P}_1(1-\hat{P}_1)}{n_1} + \frac{\hat{P}_2(1-\hat{P}_2)}{n_2} \right)^{1/2}}$$

Where P_i is the proportion of trees with their leader terminal bud attacked in treatment i, and n_i is the number of tree replicates for treatment i.

Table 2. Effect of fenvalerate and acephate treatments on incidence of spruce bud midge in terminal buds, Alaska, 1985.

Treatment	Insecticide concentration	Infested terminal buds			
		Mean number ± SE on upper 25 shoots		Proportion on leaders only	
	percent	pre-1985	1985[1]	1984	1985
Fenvalerate	0.025	3.93 ± 0.69 a[2]	1.53 ± 0.41 a	0.73	0.13 c[3]
	0.0125	3.40 ± 0.49 a	1.80 ± 0.49 ab	0.67	0.27 cd
	0.00625	3.67 ± 0.58 a	2.80 ± 0.63 ab	0.67	0.53 cd
Control	0.00000	3.47 ± 0.61 a	4.13 ± 0.84 b	0.73	0.60 d
Acephate	1.00	2.60 ± 0.65 a	3.53 ± 0.65 b	0.93	0.47 cd
	0.50	4.00 ± 0.32 a	3.27 ± 0.59 b	0.67	0.27 c
	0.25	4.33 ± 0.60 a	2.93 ± 0.63 b	0.80	0.47 cd
Control	0.00	3.47 ± 0.61 a	4.13 ± 0.84 b	0.73	0.60 d

[1] For fenvalerate, ANOV F = 3.64, P = 0.01; ANCOV F = 3.67, P = 0.01. For acephate, ANOV F = 0.55, P = 0.65; ANCOV F = 0.70, P = 0.59.

[2] Means followed by the same letter in the same subcolumn were not significantly different at *Alpha* = 0.05.

[3] Proportions followed by the same letter were not significantly different at a confidence coefficient of 0.95.

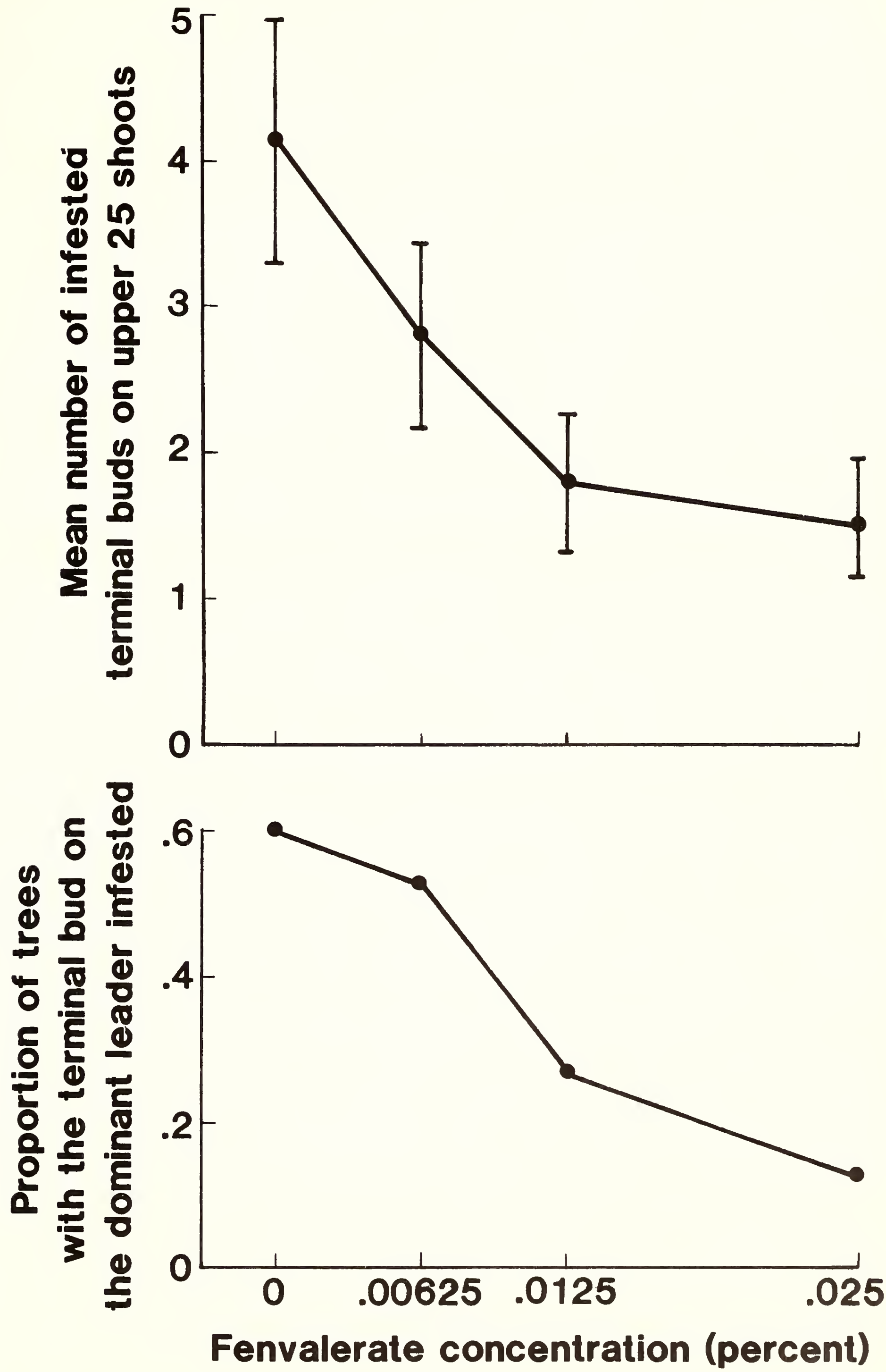

Figure 1. *Upper:* Mean number of posttreatment infested terminal buds on the upper 25 primary, secondary, and tertiary shoots combined, for fenvalerate treated and control trees. Vertical bars span ± 1 standard error.
Lower: Proportion of fenvalerate treated and control trees that had the terminal bud on the dominant leader infested in 1985.

RESULTS AND RECOMMENDATIONS

Only one white spruce received acephate treatment and one received the most concentrated fenvalerate treatment. The remaining nine white spruce were divided equally among the two less-concentrated fenvalerate treatments and the controls. Pretreatment mean number of infested buds was not significantly different for white and black spruce (for acephate and controls, $F = 0.01$, $P > 0.75$; for fenvalerate-treated trees and controls, $F = 0.41$, $p > 0.50$). Posttreatment mean number of infested buds, which were analyzed only for the three treatments that had more than one white spruce per treatment, were not significantly different for white and black spruce (for the 0.0125% fenvalerate treatment, $F = 1.37$, $P > 0.25$; for the 0.00625% fenvalerate treatment, $F = 0.79$, $P > 0.25$; and for the controls, $F = 0.14$, $P > 0.50$).

Analysis of Variance of data pooled for both species indicated no significant differences in prespray numbers of infested buds among treatments (Table 2). Furthermore, use of prespray numbers of infested buds as the covariate had essentially no effect on results of posttreatment analysis. The only treatment that provided significant protection from the spruce bud midge was 0.025% fenvalerate. Acephate could have washed off because of its solubility in water and poor rainfastness (Robertson and Boelter 1979, Haverty and Robertson 1982). But acephate's reputed systemic insecticidal activity may also be inoperative when sprayed on spruce, evidenced by Sundaram and Hopewell (1976) who failed to recover significant amounts of acephate or its systemic metabolite from spruce foliage after simulated aerial spray application.

We recommend that future insecticide trials for control of spruce bud midge include proven systemic insecticides, such as dimethoate and metasystox, and additional rainfast compounds, such as carbaryl and permethrin, that are a ready registered for use against other forest pests. We do not recommend testing higher concentrations of fenvalerate because results of this trial suggest that the maximum-effect dose has been closely approached at the 0.025% concentration (Fig. 1. Upper and lower).

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